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Comparing Futures and Survey Forecasts of Near-Term Treasury Bill Rates

PREVIOUS research indicates that Treasury bill futures rates are better predictors of the future Treasury bill rate than forward rates. In a recent paper, MacDonald and Hein (1989) analyze 44 separate contracts delivered during the period 1977-87 for forecast horizons ranging from two days ahead to 91 days ahead. Their evidence shows that the Treasury bill futures rate generally delivers a smaller forecast error of the three-month Treasury bill rate than the forward rate implicit in the spot market, and that the forward rate adds little information about future Treasury bill rates that is not already incorporated into the futures rate. There also is evidence from other studies that survey forecasts of future Treasury bill rates contain information that improve upon forward rate forecasts. Studies by Friedman (1979) and Throop (1981), for example, reveal that survey forecasts often are more accurate than the forecasts from implicit forward rates.

Given the results of this research, a natural question to ask is "Does the Treasury bill futures rate provide a better forecast of future

short-term interest rates than do survey forecasts?" In addition, since theories of financial market efficiency suggest that financial asset prices should include all available information, a related question is "Could one improve upon the Treasury bill futures forecasts using the information contained in the survey projections?"

Addressing these questions, the object of this paper, is interesting for several reasons. One is that forecasts of future interest rates are a crucial factor in forming investment strategies or purchasing plans. Incorrect interest rate forecasts can have large effects on investors' wealth. Moreover, to the extent that interest rate risk is directly related to the level of interest rates, accurately predicting the future level of rates is an important avenue to reducing interest rate risk exposure.¹ In a related vein, policymakers often consider the effect on interest rates as an important factor in predicting the outcome of policy changes. Knowing that the futures market provides an accurate gauge of the market's expectation for future rates provides a practical benchmark prediction

¹On this, see Belongia and Santoni (1987).

to which policymakers can compare their forecasts.²

This article compares futures market and survey forecasts of short-term Treasury bill rates in two ways. First, considering general accuracy, we compare forecasting results of the two predictions over the 10-year period, 1977-87. General forecast accuracy is compared along with the extent of bias in the two reported forecasts.³ Second, we investigate whether information in the survey forecast could reduce the forecast error of the Treasury bill futures market prediction. This relates to the efficiency of the Treasury bill futures market, an issue that previously has been addressed by comparing futures and forward rates in terms of the arbitrage opportunities that differentials in these two rates indicate.⁴

THE DATA

This study uses two quarterly interest rate forecasts: one from a widely circulated survey of market participants; the other from the Treasury bill futures market.

Survey Forecasts

The survey forecasts are published in the *Bond and Money Market Letter*.⁵ This survey has been taken quarterly since 1969. On each survey date, approximately 40 to 50 financial market

analysts representing a variety of financial institutions are asked for their point forecast of a number of different interest rates, three months and six months hence.⁶ In this study, we focus on the survey forecasts of the three-month Treasury bill rate. The respondents' forecasts are compiled, and the mean value is published in the *Letter*. Since the approximate date of the survey response is easily identified, these forecasts can be easily matched with futures market rates for similar dates.⁷ This feature makes the survey more attractive than other existing surveys for empirical comparison with interest rate forecasts from the futures market.⁸

Futures Market Rates

Trading in Treasury bill futures contracts takes place on the International Monetary Market (IMM) of the Chicago Mercantile Exchange between the hours of 8 a.m. and 2 p.m.⁹ The futures contracts traded call for delivery of \$1 million of Treasury bills maturing 90 days from the delivery day of the futures contract. The instrument and maturity of the deliverable instrument match well with the survey forecasts of the Treasury bill rate. These contracts call for delivery four times a year: March, June, September and December.¹⁰

The futures market forecasts were gathered so that the futures market rate was taken on the same approximate date that the survey

²As Poole (1978) notes, "Unless policymakers have solid evidence that their own forecasts are more accurate than market forecasts, they cannot afford to ignore the T-bill futures market." (p. 18)

³Belongia (1987) also compares the relative accuracy of futures and survey forecasts of Treasury bill rates, using the semiannual survey published by the *Wall Street Journal*.

⁴For examples of such studies, see Hegde and Branch (1985) or MacDonald, et al (1988) and the references cited therein.

⁵We would like to thank the publishers of the *Letter* for allowing us to use their survey results in this study. For previous analyses of this survey data, often referred to as the Goldsmith-Nagan survey, see Prell (1973), Friedman (1980), Throop (1981) and Dua (1988).

⁶The survey actually asks for forecasts of 11 different interest rates, ranging from the federal funds rate to conventional mortgage rates.

⁷The newsletter in which the survey results are published also provides the interest rates on the day the questionnaires are mailed and the latest close before publication, a period of about two weeks.

⁸One such survey is conducted by the American Statistical Association-National Bureau of Economic Research (ASA-NBER). This quarterly survey also asks participants to

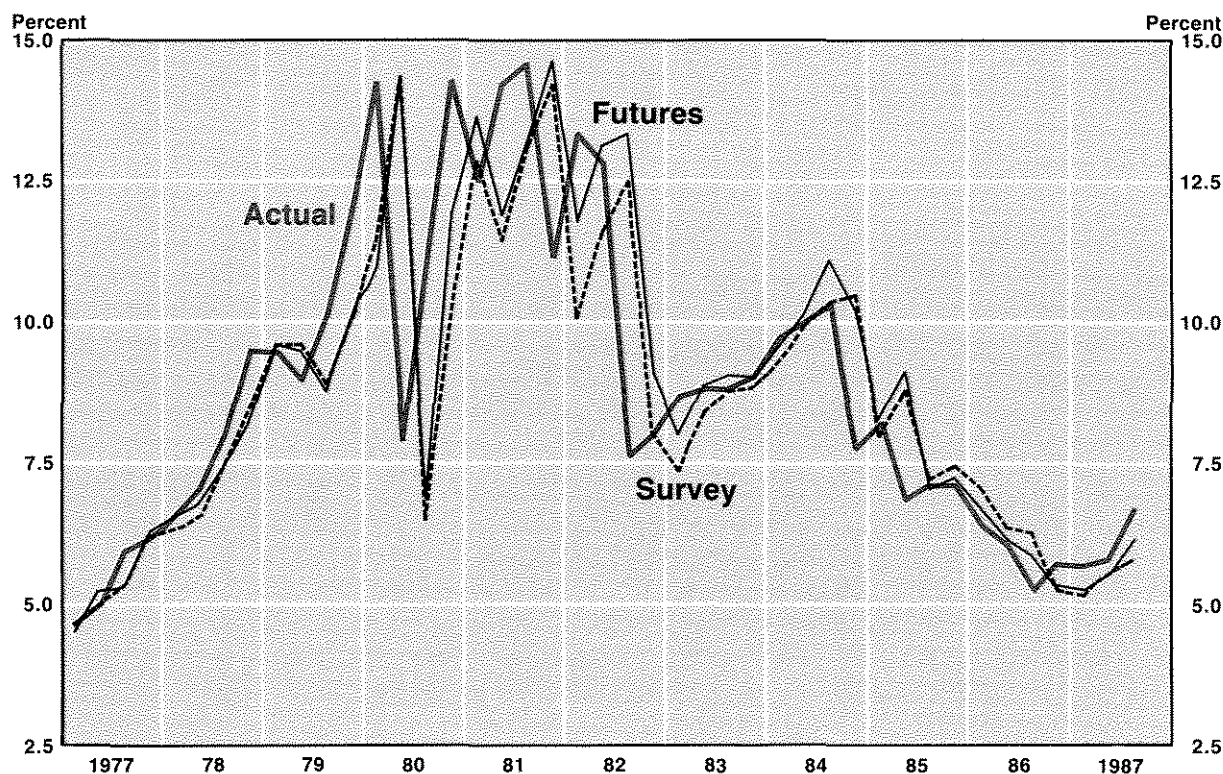
forecast the Treasury bill rate one quarter and two quarters ahead. Unfortunately, the questionnaire does not ask respondents for a forecast of the rate on any certain date in the future. It is unclear, therefore, whether the resulting forecast is a quarterly average, the peak rate for the quarter or the rate expected to hold at quarter's end.

Another interest rate survey already referred to is the semiannual *Wall Street Journal* poll of financial market analysts. This survey asks participants for their forecast of the three-month Treasury bill rate six months hence. Because this survey has been conducted only since December 1981, the limited number of forecasts restricts its usefulness for the type of empirical analysis used in this study.

⁹The discussion of the futures contract is based on information available in the 1983 *Yearbook* of the IMM and the 1987 *Yearbook*, volume 2, of the Chicago Mercantile Exchange.

¹⁰The volume of futures contracts traded on the IMM grew substantially from their introduction in January 1976, when the total volume for all delivery months was 3,576 contracts, through August 1982, when the number of contracts traded reached 738,394. Since 1982, however, the number of contracts traded has decreased: in December 1987, the total number of contracts was 131,575. The decline in the Treasury bill contracts also coincides with the introduction of a Eurodollar futures contract. This new contract may be viewed as a substitute for the Treasury bill contract.

Figure 1
T-Bill, Futures and Survey Forecasts
Forecast Horizon: Three Months



forecast was made. It is the approximate date, because the exact date when each survey respondent made his or her forecast cannot be determined. For example, the questionnaire asking "At what level do you see the following rates on September 30, 1987, and December 31, 1987?" was mailed to survey participants on June 16, 1987. The results of this survey subsequently were published on July 2, 1987.

To make the analysis in this study tractable, we have chosen the midpoint of this two-week interval between the mailing date and publication date as the representative forecast date. Continuing with the example, two Treasury bill futures contracts were gathered from the *Wall Street Journal* for June 24, 1987: those for the September and December 1987 delivery dates.¹¹ These futures market predictions are then

directly compared with the three-month and six-month-ahead Treasury bill rate survey forecasts published on July 2, 1987. For example, the July 1987 survey forecast of the September 30, 1987, Treasury bill rate was 5.81 percent. The futures market forecast was slightly higher, 6.15 percent. The actual rate turned out to be 6.64 percent.

A PRELIMINARY LOOK AT THE FORECASTS

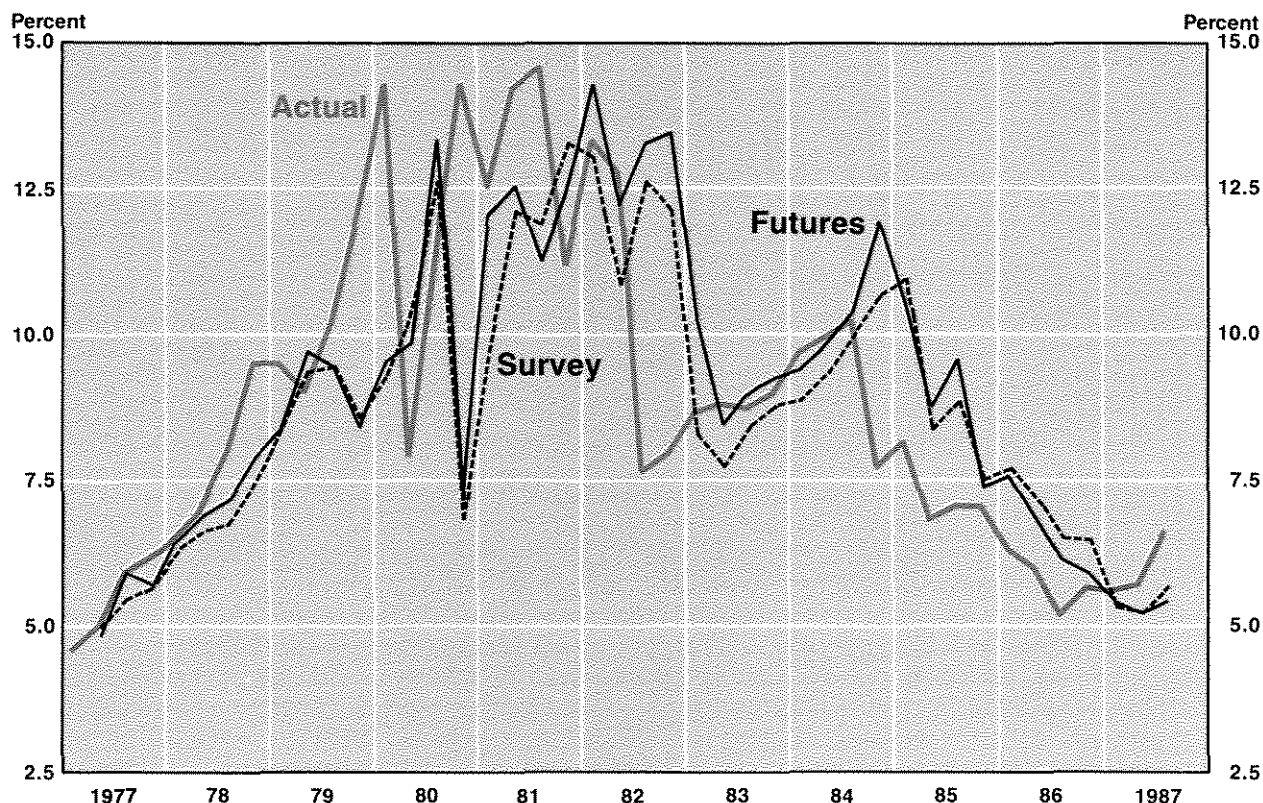
To illustrate the overall relationship between the different series over the full sample period, we plotted the actual three-month Treasury bill rate and the different forecasts for the full sample period, from March 1977 through October 1987. These are shown in figures 1 and 2.

¹¹It also should be noted that a slight disparity between the date of the two forecasts is expected to prevail. The survey participants presumably are projecting rates for the last business day of each quarter. Alternatively, the futures

market is concerned with rates on the delivery day of the futures contract, usually the third Thursday of the final month in each quarter. The maximum disparity, however, is only six business days.

Figure 2 T-Bill, Futures and Survey Forecasts

Forecast Horizon: Six Months



Three-Month-Ahead Forecasts

Figure 1 presents the two different three-month-ahead forecasts along with the actual three-month Treasury bill rate. The general pattern shown is similar for both forecasts. In fact, both appear to have a closer relationship to each other than they do to the actual Treasury bill rates. For example, both forecasts over-predicted the actual rate in 1980.¹² The forecast error (actual minus predicted) for June 1980 from the futures market was -630 basis points; for the survey it was -642 basis points. Another relatively large forecasting error occurred when the actual rate fell sharply in late 1982. For September 1982, the futures market

forecast error is -571 basis points compared with the survey forecast error of -487 basis points. Since 1984, although the differences have become smaller, the forecast errors from the futures market and the survey have tended to systematically overpredict rates.

To provide some statistical basis for assessing the accuracy of these two forecasts, table 1 presents summary measures of the relative accuracy of the two three-month Treasury bill forecasts over the full period and two subperiods.¹³ Both the mean absolute error (MAE) and the root mean squared error (RMSE) are reported for the forecasts. As a benchmark, we also report the results based on a simple no-

¹²The Special Credit Control program was administered during this period. For a description of the program and a discussion of monetary policy during this period, see Gilbert and Trebing (1981).

¹³These subperiods represent those during which monetary policy was thought to be influenced by the behavior of the

monetary aggregates (1980-82) and the behavior of interest rates (1983-87). Gilbert (1985) and Thornton (1988) suggest that the behavior of policy under borrowed reserve targeting was quite similar to that under a federal funds rate targeting procedure.

Table 1
Summary Forecast Statistics, Three-Month Treasury Bill Rate

Forecast	March 1977- October 1987		March 1980- December 1982		March 1983- October 1987	
	MAE	RMSE	MAE	RMSE	MAE	RMSE
Three-month forecasts						
Futures	1.18%	1.90%	2.79%	3.32%	0.53%	0.86%
Survey	1.25	1.97	2.92	3.44	0.62	0.93
Naive	1.20	1.91	3.10	2.53	0.54	0.79
Six-month forecasts						
Futures	1.52	2.28	2.94	3.64	1.03	1.48
Survey	1.60	2.23	3.10	3.63	1.03	1.30
Naive	1.68	2.31	3.12	3.63	0.83	1.01

NOTE: MAE is the mean absolute error; RMSE is the root mean squared error.

change forecast model, where the no-change model's forecast is the spot three-month Treasury bill rate observed on the same day that the futures rate forecast also is gathered.

The overall forecast accuracy of the three-month-ahead futures and survey predictions are quite close. For the full period, the MAE is 1.18 percent for the survey and 1.25 percent for the futures rate, both about the same as the no-change forecast (1.20 percent). The RMSEs also are quite similar across forecasts. The subperiod results reflect the difficulty in forecasting the Treasury bill rate during the early 1980s: the MAEs for the different forecasts are, on average, five times greater during the 1980-82 period than the 1983-87 period. Still, the forecast statistics indicate that the relative accuracy of the forecasts is similar.¹⁴

Six-Month-Ahead Forecasts

Figure 2 is a plot of the six-month-ahead forecasts together with the actual Treasury bill rate. The size and pattern of the two six-month-ahead forecast errors contrasts sharply with the three-month-ahead forecasts. Note, for example, the relative magnitude of the forecast errors

during 1980 in figure 2 contrasted with figure 1. The prediction error for December 1980 from the futures rate was -704 basis points and, for the survey forecast, -744 basis points. For the three-month-ahead forecasts, the respective errors were positive and smaller: 239 basis points for the futures market forecast and 409 basis points for the survey forecast. Note also the magnitude of the post-1984 overprediction in figure 2 relative to figure 1.

The summary statistics in table 1 reveal that the accuracy of the six-month-ahead futures and survey forecasts is comparable for the full period and the subperiods. Generally, there is little difference between the MAEs and RMSEs for the two forecast series.

Bias Tests

Observers generally argue that rational individuals do not make the same forecasting mistake over and over again, because forecasts that consistently over- or underpredict the actual series presumably reduce the investor's wealth relative to forecasts that are unbiased. Consistent with the notion of wealth-maximization and rationality, forecasts therefore should be unbiased.

¹⁴This observation is corroborated by a statistical test of the futures and survey forecasts' mean square errors (MSE). This test, suggested by Ashley, Granger and Schmalensee

(1980), revealed that one could not reject the hypothesis that the futures market and survey forecasts' MSEs are equal.

To test forecasts for bias, researchers usually estimate a regression of the form

$$(1) r_t = \alpha + \beta_{t-s} r_t^E + u_t,$$

where r_t is the actual rate of interest at time t , ${}_{t-s}r_t^E$ is the expectation of the rate for time t held at time $t-s$, and u_t is a random error term.¹⁵ The null hypothesis, that expectations are unbiased, implies the testable hypothesis that the estimated values of the coefficient α is zero and the coefficient β is unity. Moreover, the error term (u_t) should not display characteristics of autocorrelation.¹⁶

A problem in estimating equation 1 arises if the actual and forecast series are characterized by unit root processes.¹⁷ In such a case, estimating equation 1 will produce downward-biased coefficient estimates, an increased probability of rejecting the null hypothesis and, therefore, an incorrect finding of bias when it doesn't exist.¹⁸

As an alternative to estimating equation 1 directly, one can test for bias by imposing the null hypothesis conditions and determine whether the data reject them. Imposing the null restrictions yields the relationship

$$(2) r_t - {}_{t-s}r_t^E = u_t.$$

If the actual interest rate series and the forecasts are characterized by unit root processes and the forecasts are unbiased, then the data also should reject the hypothesis that the

forecast error (u_t) has a unit root. Moreover, it should be the case that $E(u_t) = 0$.

To implement this test procedure, we first test for unit roots in the actual and forecast interest rate series. Again, if it is shown that the actual interest rate series has a unit root, then so should the forecast series under the assumption of rational expectations.¹⁹ To test for unit roots, the Dickey-Fuller (1979) test procedure is used wherein the change in each series is regressed on a constant and one lagged value of the series's level. Specifically, a regression of the form

$$(3) \Delta X_t = \alpha_0 + \lambda X_{t-1} + e_t$$

is estimated, where Δ is the difference operator (i.e., $\Delta X_t = X_t - X_{t-1}$). If the t-ratio associated with the lagged variable is less than the relevant critical value, then we can reject the existence of a unit root.

The results of this test for the Treasury bill rate and its forecasts are reported in the upper half of table 2. In every instance, we find that the estimated t-ratio on the lagged level of the selected variable is greater than the 5 percent critical value, about -3.50 .²⁰ This evidence indicates that we cannot reject the notion that each series has a unit root.

Given this finding, the forecast errors are examined to determine whether they do not contain unit roots, as hypothesized under the con-

¹⁵Webb (1987) has argued that such tests may lead one to reject the null hypothesis when it is true. He argues that rejection of unbiasedness may reflect several factors, all of which are known to the econometrician *ex post* but not to the forecaster *ex ante*. He argues that forecasts that fail bias tests may in fact have originally been formulated optimally. This criticism is most forceful for examining forecasts of series that are revised many times following the original forecast date. Such a problem does not exist, however, with the interest rate series used here.

¹⁶This restriction, as Friedman (1980) notes, strictly applies only to the one-step-ahead forecasts.

¹⁷If the fundamental moving-average representation of some series X has an autoregressive representation, then it can be written in the form

$$[1-a(L)]X_t = e_t,$$

where L is the lag operator (i.e., $LX_t = X_{t-1}$ and $a(L) = \sum a_i L^i$). The polynomial in the lag operator $a(L)$ can be written as $a(L) = (1-B_1L)B(L)$. If there exists a root B_1 that is equal to unity, then the series X is characterized by a unit root. It is useful to note that a random walk is a particular type of unit-root process.

¹⁸We would like to thank Jerry Dwyer for pointing this out. This issue is discussed at length in Dwyer, et al (1989) from which the following draws.

¹⁹In other words, the process generating the expectations should be the same as the one generating the actual series.

²⁰The critical value is taken from Fuller (1976), table 8.5.2. We should note that Schmidt (1988), extending the work of Nankervis and Savin (1985), argues that these critical values are incorrect in the presence of significant drift in the variable. Given the estimated constant terms found in the upper panel of table 2, the critical value to test for unit roots according to Schmidt is about -1.86 at the 5 percent level and about -2.60 at the 1 percent level. Using these critical values, our estimates suggest that, while unit roots are rejected at the 5 percent level, they are not at the 1 percent level.

If we take the results using the 5 percent level, then it is possible to estimate equation 1 directly. Doing so gives the following results: the calculated F-statistic and related marginal significance level testing the joint hypothesis that $\alpha = 0$ and $\beta = 1$ in equation 1 is 2.51 (0.09) for the three-month futures forecast; 3.26 (0.05) for the six-month futures forecast; 1.66 (0.20) for the three-month survey forecast; and 1.80 (0.18) for the six-month survey forecast. Except for the six-month futures forecast, these results indicate that unbiasedness cannot be rejected.

Table 2

Unit Root Tests on Actual Treasury Bill and Forecasts
Sample: March 1977-October 1987

Actual series	Estimated coefficient ¹	
	Constant	Lagged level
Treasury bill	2.17 (2.34)	-0.239 (-2.40)
Futures (3-month)	2.40 (2.40)	-0.263 (-2.48)
Survey (3-month)	2.84 (2.70)	-0.321 (-2.79)
Futures (6-month)	2.21 (2.26)	-0.240 (-2.34)
Survey (6-month)	2.07 (2.26)	-0.234 (-2.32)
Forecast errors		
Futures (3-month)	-0.112 (-0.37)	-1.203 (-7.66)
Survey (3-month)	0.201 (0.64)	-1.214 (-7.76)
Futures (6-month)	-0.122 (-0.35)	-0.698 (-4.55)
Survey (6-month)	0.128 (0.37)	-0.702 (-4.59)

¹Values of t-ratios are reported in parentheses. The 5 percent critical value taken from Fuller (1976) is about -3.50.

dition of unbiasedness.²¹ Regressing the change in the respective forecast error on a constant and a lagged level of the forecast error produces the results reported in the lower half of table 2. For both the three-month and six-month forecasts, the futures market and survey forecasts of the Treasury bill rate satisfy the condition of unbiasedness: the calculated t-ratio is

always less than the critical value. These results indicate that the imposed restrictions associated with unbiased forecasts are not rejected.

The different forecast error series also are examined to decide whether their mean values differ from zero. In every instance, the hypothesis that the mean forecast error is not statistically different from zero could not be rejected. In fact, the largest t-statistic calculated is far below unity. Thus, the evidence is largely consistent with the notion that the futures market and survey forecast errors are unbiased.²²

MARKET EFFICIENCY TESTS

The evidence to this point tells us little about the efficiency of the Treasury bill futures market. The hypothesis of market efficiency asserts that financial markets use all available information in pricing securities. If this is true, there should be no more accurate forecast of future security prices than that in today's price.

To investigate the efficiency of the futures market forecasts, a test proposed by Throop (1981) is used to determine whether knowledge of the survey forecast of Treasury bill rates could reduce the forecast error made by the futures market. The answer to this question can be found by estimating the regression

$$(4) \quad r_t - {}_{t-s}r_t^F = \delta({}_{t-s}r_t^S - {}_{t-s}r_t^F) + e_{s,t},$$

where r_t is the three-month Treasury bill rate at date t , ${}_{t-s}r_t^F$ is the futures market rate at $t-s$ for delivery at t , ${}_{t-s}r_t^S$ is the survey forecast taken at $t-s$ for rates prevailing at t and $e_{s,t}$ is a random error term.²³ The hypothesis of market efficiency requires that the estimated value of the coefficient δ is zero, indicating that the information in the survey forecast already is incorporated in the futures market's projection. To see this, rewrite equation 4 as $r_t = \delta {}_{t-s}r_t^S + (1-\delta){}_{t-s}r_t^F$. Under the market efficiency requirement that $\delta = 0$, the survey forecast drops

²¹As Dwyer, et al (1989) state, "A unit root in the forecast errors would indicate that the distribution of the forecast errors has a random walk component which has no counterpart in the innovations in the events being forecast." (p. 15)

²²The bias of the no-change forecasts also was tested. Like the results based on the futures market and survey forecasts, the reported t-ratios allow us to reject the hypothesis of a unit root in the forecast errors of the no-change models. Moreover, the mean forecast error is not statistically different from zero.

²³Throop (1981) used this approach to test the efficiency of Treasury bill forward rate projections and found evidence of inefficiencies in the forward market. Kamara and Lawrence (1986) and MacDonald and Hein (1989) use this approach and find that Treasury bill futures rates are more accurate forecasts when compared with the forward rates. Other examples employing a similar type of analysis are Fama (1984a,b) and French (1986).

Table 3
Efficiency Test Regressions
Sample: March 1977-October 1987

Estimated Equations:

A) $r_t - {}_{t-1}r_t^F = \delta_1({}_{t-1}r_t^S - {}_{t-1}r_t^F)$

B) $r_t - {}_{t-1}r_t^F = \delta_2(r_t - {}_{t-1}r_t^F)$

Equation	Estimated coefficients		R ²	DW
	d ₁	d ₂		
Three-month forecasts				
A	0.08 (0.16)		-0.02	2.41
B		0.44 (0.95)	0.02	2.50
Six-month forecasts				
A	0.71 (1.54)		0.05	1.40
B		0.44 (1.36)	0.04	1.58

NOTE: Absolute value of t-statistics in parentheses.

from the equation and one is left with
 $r_t = {}_{t-1}r_t^F + e_{s,t}$.

If the estimated value of δ is different from zero, however, knowledge of the differential between the survey forecast and the futures rate would significantly reduce the forecast error in the futures rate.²⁴ This would be inconsistent with the notion that market participants efficiently utilize all available information. In the terminology of Fama (1970), our test is a "semi-strong" form test of market efficiency, since all the information in the survey projections would not have been publicly available when the futures market was sampled.

Estimates of equation 4 to test the efficiency of both the three-month-ahead and the six-

month-ahead Treasury bill futures market forecasts are reported as equation A in table 3.²⁵ The evidence indicates that the hypothesis of a semi-strong form of market efficiency cannot be rejected at the 5 percent level of significance. Using the information differential between the survey forecast and the futures rate, the estimated value of δ is only 0.08 ($t = 0.16$) for the three-month forecast horizon. For the six-month horizon, the estimated value of δ is 0.71 ($t = 1.54$). In both instances, we cannot reject the hypothesis of efficiency as applied to the futures market forecast. A weak-form market efficiency test also was considered by replacing the survey forecast with the current spot market rate. The result is reported as equation B in table 3. When compared with the no-change forecast, efficiency again cannot be rejected for the futures rate: the results indicate that, for the three-month and six-month forecasts, the estimated value of δ is never significantly different from zero.

Rewriting equation 4 as above also indicates that it imposes the restriction that the sum of the weights on the two forecasts sum to unity. We have re-estimated the equation without this restraint and found that we still could not reject efficiency of the futures rate forecasts when compared with either the survey or no-change forecasts.

The Role of the Revision in the Survey Forecast

Since the survey participants are asked for their three- and six-month-ahead forecasts every three months, they essentially are providing two forecasts of the same event, taken at two different points in time. For example, survey participants are asked in December of the previous year and then again in March to forecast the June Treasury bill rate. One piece of new information that survey respondents have in making their March forecasts is the revision of the December forecast itself. Nordhaus (1987) has suggested that, for forecasts to be efficient, the information in the revision also should be incor-

²⁴This same procedure can be used to test if there is information in the futures rate that is not present in the survey forecast. In this case, the left-hand side of equation 4 is the forecast error from the survey prediction. The results from this test (not reported) indicate that the survey forecasts are efficient with respect to the futures market forecasts.

²⁵The results reported are those excluding a constant term in the regression. Including a constant term does not alter the conclusions reached. Also, White's (1980) test failed to reject the null hypothesis of homoskedasticity in the residuals.

porated in the current forecast. Knowledge of the revision should not allow a reduction in the forecast error under the hypothesis of efficiency.

A similar argument can be applied to the futures rate forecasts. In particular, knowledge of the revision in the survey forecast of future Treasury bill rates should not help reduce the futures market's forecast error if the latter is formed efficiently. The survey's revision is part of today's information set and should already be incorporated into the market's projection.²⁶ To test whether knowledge of the survey's revision could help reduce the forecast error in the futures market, equation 4 is modified to include the survey revision itself:

$$(5) \quad r_t - {}_{t-1}r_t^F = \alpha_0 + \gamma_1({}_{t-1}r_t^S - {}_{t-1}r_t^F) \\ + \gamma_2({}_{t-1}r_t^S - {}_{t-2}r_t^S) + e_t.$$

The term $({}_{t-1}r_t^S - {}_{t-2}r_t^S)$ reflects the revision in the survey's forecast of next quarter's Treasury bill rate. Efficiency requires not only that the futures rate contains all the information in the survey forecast, but also that it reflects the survey forecast revision. If the futures rate forecast is efficient, estimated values of both γ_1 and γ_2 in equation 5 should not be different from zero.

The results from estimating equation 5 (with absolute value of t-statistics in parentheses) are:²⁷

$$(6) \quad r_t - {}_{t-1}r_t^F = -0.066 + 0.104({}_{t-1}r_t^S - {}_{t-1}r_t^F) \\ (0.20) \quad (0.18) \\ -0.312({}_{t-1}r_t^S - {}_{t-2}r_t^S) \\ (1.86)$$

$$\bar{R}^2 = 0.034 \quad DW = 1.92$$

The intercept of the equation is not statistically different from zero, indicating no bias in these projections. We also find that the estimated slope coefficients (γ_1 and γ_2) are not

significantly different from zero using a conventional 5 percent level of significance. This outcome is consistent with the efficient markets hypothesis that there is little information in the survey forecast or its revision that is not already incorporated into the futures rate forecast.²⁸

CONCLUSION

In this study, we compared futures market and survey forecasts of the three-month Treasury bill rate both three and six months ahead. Our test results generally support the perception that the forecasts are unbiased predictors of future rates. Moreover, futures market forecasts of near-term interest rates usually are as accurate as those produced by professional forecasters. Compared with a popular survey of professionals used in this study, we find little difference in the relative forecasting accuracy of the two. Our results also indicate that no information in the survey forecast or its revision could reliably improve upon the futures rate prediction.

This conclusion about market efficiency contrasts sharply with that found for the forward market. Previous evidence has shown that the Treasury bill forward rate does not incorporate all of the information contained in the same survey considered here. Such a conclusion, along with the evidence presented in this paper, is consistent with the belief that there is a time-varying premium in the forward rate that apparently is absent in the Treasury bill futures rate.

The results presented here should not be interpreted as proof that the Treasury bill futures market rate is always the most accurate interest rate forecast. The evidence does suggest, however, that for investment decisions and monetary policy discussions, the futures rate provides a useful measure of the market's expectation of future interest rates. Consequently, it is a valuable benchmark to which other forecasts can be compared.

²⁶The reader again is reminded that this is a semi-strong form efficiency since the information in the survey revision would not have been released to the public at the time that we sampled the futures rates.

²⁷White's (1980) test indicated that we could not reject the null of homoskedastic residuals.

²⁸We should note, however, that the γ_2 slope coefficient is significant at about the 7 percent level. Based on this level of significance, the result of estimating equation 5 is consistent with the notion that the futures rate forecasts may

not be the optimal projection of the Treasury bill rate. Given the results in equation 6, the optimal forecast $({}_{t-1}r_t^o)$ would take the form

$${}_{t-1}r_t^o = {}_{t-1}r_t^F - 0.312({}_{t-1}r_t^S - {}_{t-2}r_t^S).$$

This result implies an overreaction on the part of the futures market to a revision. That is, if the survey revises its interest rate forecast upward, the optimal forecast would scale down the forecast from the futures market.

REFERENCES

- Ashley, Richard, Clive W. J. Granger, and Richard Schmalensee. "Advertising and Aggregate Consumption: An Analysis of Causality," *Econometrica* (July 1980), pp. 1149-67.
- Belongia, Michael T. "Predicting Interest Rates: A Comparison of Professional and Market-Based Forecasts," this *Review* (March 1987), pp. 9-15.
- Belongia, Michael T., and Gary J. Santoni. "Interest Rate Risk, Market Value, and Hedging Financial Portfolios," *Journal of Financial Research* (Spring 1987), pp. 47-55.
- Chicago Mercantile Exchange. 1987 *Yearbook* (1988).
- Dickey, David A., and Wayne A. Fuller. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association* (June 1979), pp. 427-31.
- Dua, Pami. "Multiperiod Forecasts of Interest Rates," *Journal of Business and Economic Statistics* (July 1988), pp. 381-84.
- Dwyer, Gerald P., Jr., Arlington W. Williams, Raymond C. Battalio, and Timothy I. Mason. "Tests of Rational Expectations in a Stark Setting," Federal Reserve Bank of St. Louis Research Paper 89-001 (April 1989).
- Fama, Eugene F. "Forward and Spot Exchange Rates," *Journal of Monetary Economics* (November 1984a), pp. 319-38.
- _____. "The Information in the Term Structure," *Journal of Financial Economics* (December 1984b), pp. 509-28.
- _____. "Efficient Capital Markets: A Review of Theory and Empirical Work," *Journal of Finance* (May 1970), pp. 383-417.
- French, Kenneth R. "Detecting Spot Price Forecasts in Futures Prices," *Journal of Business* (April 1986), pp. 539-54.
- Friedman, Benjamin M. "Survey Evidence on the 'Rationality' of Interest Rate Expectations," *Journal of Monetary Economics* (October 1980), pp. 453-65.
- _____. "Interest Rate Expectations Versus Forward Rates: Evidence from an Expectations Survey," *Journal of Finance* (September 1979), pp. 965-73.
- Fuller, Wayne A. *Introduction to Statistical Time Series* (John Wiley & Sons, Inc., 1976).
- Gilbert, R. Alton. "Operating Procedures for Conducting Monetary Policy," this *Review* (February 1985), pp. 13-21.
- Gilbert, R. Alton, and Michael E. Trebing. "The FOMC in 1980: A Year of Reserve Targeting," this *Review* (August/September 1981), pp. 2-22.
- Hegde, S., and B. Branch. "An Empirical Analysis of Arbitrage Opportunities in the Treasury Bills Futures Market," *Journal of Futures Markets* (Fall 1985), pp. 407-24.
- International Monetary Market. 1983 *Yearbook* (Chicago Mercantile Exchange: 1984).
- Kamara, A., and C. Lawrence. "The Information Content of the Treasury Bill Futures Market Under Changing Monetary Regimes," Working Paper No. 51 (Center for the Study of Banking and Financial Markets, University of Washington, 1986).
- MacDonald, S. Scott, and Scott E. Hein. "Futures Rates and Forward Rates as Predictors of Near-Term Treasury Bill Rates," *Journal of Futures Markets* (June, 1989) pp. 249-62.
- MacDonald, S. Scott, Richard L. Peterson, and Timothy W. Koch. "Using Futures to Improve Treasury Bill Portfolio Performance," *Journal of Futures Markets* (April 1988), pp. 167-84.
- Nankervis, J. C., and N. E. Savin. "Testing the Autoregressive Parameter with the t Statistic," *Journal of Econometrics* (February 1985), pp. 143-61.
- Nordhaus, William D. "Forecasting Efficiency: Concepts and Applications," *Review of Economics and Statistics* (November 1987), pp. 667-74.
- Poole, William. "Using T-bill Futures to Gauge Interest-Rate Expectations," Federal Reserve Bank of San Francisco *Economic Review* (Spring 1978), pp. 7-19.
- Prell, Michael J. "How Well do the Experts Forecast Interest Rates?" Federal Reserve Bank of Kansas City *Monthly Review* (September-October 1973), pp. 3-13.
- Schmidt, Peter. "Dickey-Fuller Tests with Drift," unpublished manuscript, Michigan State University (June 1988).
- Thornton, Daniel L. "The Borrowed-Reserves Operating Procedure: Theory and Evidence," this *Review* (January/February 1988), pp. 30-54.
- Throop, Adrian W. "Interest Rate Forecasts and Market Efficiency," Federal Reserve Bank of San Francisco *Economic Review* (Spring 1981), pp. 29-43.
- Webb, Roy H. "The Irrelevance of Tests for Bias in Series of Macroeconomic Forecasts," Federal Reserve Bank of Richmond *Economic Review* (November/December 1987), pp. 3-9.
- White, Halbert. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity," *Econometrica* (May 1980), pp. 817-38.